Effect of Soil Water Potential on Growth of Apple Trees Infected with Pratylenchus penetrans

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Abstract: Malling-Merton 106 apple rootstocks inoculated with *Pratylenchus penetrans,* or uninoculated, were grown in a growth chamber in pots of loamy sand maintained at two moisture levels, 0 to −0.4 bar or 0 to −10 bars. Either inoculation or low soil moisture suppressed shoot growth and increased root necrosis. However, the nematode-soil moisture interaction was not significant. *Key Words:* root-lesion nematodes, nematode-soil moisture interaction.

Damage of apple trees (*Malus domestica,* Borkh.) by *Pratylenchus penetrans* (Cobb) Filipjev and Schuurmans Stekhoven is usually more severe on well-drained sandy soils (5), suggesting that low soil moisture may contribute to tree decline. Although high soil moisture (near field capacity) has been shown to favor the movement of certain plant-parasitic nematodes (8), including *P. penetrans* (3), the influence of soil moisture on symptom expression is not clear. Field observations indicate that plants infected with *Meloidogyne* spp. are harmed by "droughty" conditions more than are healthy plants (1). On the other hand, Townshend and Webber (7) found that symptom expression associated with *P. penetrans* on tobacco was obscured under a low soil-moisture regime. The present investigation of the effect of soil moisture on apple trees infected with *P. penetrans* sought to answer two closely related questions: 1) Are the detrimental effects of *P. penetrans* and low soil moisture synergistic? 2) Does a high soil-moisture regime compensate for damage caused by *P. penetrans*?

MATERIALS AND METHODS

General procedures: The soil used was a loamy sand collected from an apple orchard in Wayne County, New York (2). It was autoclaved at least 1 month before planting. One-year-old dormant unbudded Malling-Merton 106 rootstocks about 1 cm in diameter, purchased from a commercial nursery,

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Received for publication 18 August 1978.

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contained less than one *Pratylenchus* spp./g root. The trees were pruned to 40 cm total length and the roots were pruned to 1 cm. The dormant trees were planted in 13-cm-diam plastic pots and placed in a growth chamber, and after 2 weeks all shoots but one were removed. The growth chamber was maintained at 20 C, a 15-hr photoperiod, and 21,000 lux. Humidity was not monitored. A soluble fertilizer (23-19-17) was applied to the rootstocks 8, 22, 36, and 50 days after planting. Source of inoculum and method of inoculation and extraction have been described (2, 4, 6).

Inoculum level: In order to select an inoculum level for experiments in which soil moisture potential would be a variable, MM.106 rootstocks were inoculated 20 days after planting with 0, 1,000, 10,000, 25,000, or 50,000 *P. penetrans*/pot. There were eight trees per treatment except in the treatments of 10,000 and 50,000 *P. penetrans*/pot, in which there were 12 trees per treatment. Fourteen days after inoculation, four randomly selected trees receiving 10,000 *P. penetrans*/pot were harvested, and the number of *P. penetrans*/pot was determined to assess the number of nematodes surviving inoculation. By 90 days after planting, shoot elongation had ceased and the experiment was terminated.

Nematode-soil moisture interaction: The effect of soil water potential was examined in an experiment (repeated once) containing four treatments: a high and low moisture regime ± inoculation with 35,000 *P. penetrans*/pot. Each treatment contained at least eight replicate trees. Tensiometers (Irrometer Co., Riverside, California) were used to monitor soil water potential in the high-moisture regime, and soil psychrometers (PT-51-05 Thermocouple Psychrometer; Wescor, Inc., Logan, Utah) were used in the low-moisture regime. Psychrometers were tested for accuracy in solutions of KCl at –4.5, –11.1, and –21.9 bars as described by Weibe *et al.* (9). In the first experiment, the mean reading of psychrometers placed in a KCl test solution of –11.1 bars was –10.3 bars (standard error = 0.18 bar; range = –8.2 to –12.5 bars). In the second experiment, the mean reading of psychrometers placed in a test solution of –11.1 bars was –11.1 bars (standard error = 0.12 bar; range = –10.1 to –11.9 bars). Tensiometers and psychrometers were placed in the pots at planting. Each was located in the center of the pot, about 5 cm from the bottom. In each of the high-moisture treatments (± *P. penetrans*), three of the eight pots contained tensiometers. When a mean reading of about –0.4 bar was recorded with tensiometers within a particular treatment, sufficient water was added to all pots in the treatment to raise their soil water potentials to about 0 bars. In the two low-moisture treatments (± *P. penetrans*) each pot contained one psychrometer. When a mean reading of about –10 bars was recorded in either low-moisture treatment, sufficient water was added to all pots in that treatment to raise their soil water potential to about 0 bars. [Readings were made with a HR-33T Dew Point Microvoltmeter; Wescor, Inc., Logan, Utah.]

The trees were placed in the growth chamber on day 0. On day 20, half the trees were inoculated with 35,000 *P. penetrans*/pot. From day 0 to initiation of the low-moisture regime, all trees were maintained under a high soil-moisture regime. When shoot lengths averaged about 45 cm (day 70 in the first experiment and day 54 in the second), low soil-moisture regimes were initiated in half of the inoculated and uninoculated trees whereas the remaining trees continued to be maintained under a high soil-moisture regime. About 2 weeks after shoot elongation had ceased (day 120 in the first experiment and day 94 in the second) the experiment was terminated.

RESULTS

Inoculum level: Inoculation with 50,000 *P. penetrans*/pot significantly reduced shoot and root weight and significantly increased root necrosis (Table 1). Lower numbers of *P. penetrans* did not reduce the growth of the apple trees significantly in the period of the experiment. An arithmetic reduction at 25,000 *P. penetrans*/pot suggested that this might be slightly less than the number required to cause significant growth reduction. Thus, 35,000 *P. penetrans* were used as an inoculum level in experiments with soil water potential. Four trees in the 50,000/pot treatment died. One tree died in each of the 25,000 and 10,000/pot treatments. No trees died in the other treatments. Only 14% of the inoculum added to

TABLE 1. The effect of different levels of *Pratylenchus penetrans* on the shoot weight, root weight, and root necrosis of MM.106 apple rootstocks.

Inoculum level	*P. penetrans* /g root[x]	*P. penetrans* /100 cc soil[x]	Shoot fresh wt (g)	Root fresh wt (g)	Root necrosis index[y]
0	0	0	31.6 ab	10.9 a	1.5 a
1,000	41	6	37.3 a	12.2 a	1.9 a
10,000	228	57	33.8 ab	10.5 a	1.9 a
25,000	685	67	27.9 abc	9.9 a	1.9 a
50,000	1,008	175	19.4 c	6.3 b	3.1 b

[x] Recovered at harvest.

[y] Root necrosis was rated on a scale of 1–5: 1 = 0–20% necrosis; 5 = 81–100% necrosis.

Means in a column followed by same letter are not significantly different at the 5% level as determined by Duncan's multiple-range test.

the 50,000 and 10,000/pot treatments was recovered 14 days after inoculation. The number of *P. penetrans*/g root recovered at the end of the experiment (Table 1) was within the range of counts obtained from New York apple orchards.

Nematode-soil moisture interaction: Inoculation with *P. penetrans* suppressed shoot weight and increased root necrosis in both moisture regimes (Table 2). Inoculation did not affect root weight. Maintenance of a low-moisture regime suppressed shoot and root weight and generally increased root necrosis. There was no interaction between inoculum levels and moisture levels for any of the variables measured, as assessed by the *t*-test (P = 0.05). The increase in shoot and root weight between initiation of the low-moisture regime and the end of the experiment was also determined and these data reaffirm the previous statements. No trees died in any treatment. Nematode counts did not differ between inoculated treatments (Table 2).

DISCUSSION

The results indicate that the detrimental effects of *P. penetrans* and low soil moisture are not synergistic, i.e., uninfected and infected trees responded similarly to low soil moisture. Furthermore, a moisture regime near optimum for tree growth did not compensate for damage caused by *P. penetrans.* This suggests that growers must manage both nematodes and soil moisture to realize maximum tree performance.

These results cannot be related directly to the field or even other growth-chamber systems without qualification. The experiment included only two levels of inoculum, two moisture regimes, and one apple rootstock. The relationship between *P. penetrans* and the apple tree might change as a function of such factors. The relative times of inoculation and initiation of the low-moisture regime might also have altered the results. Finally, *P. penetrans* may influence the water relations of apple trees

TABLE 2. The effect of high and low soil-moisture regimes on shoot weight, root weight, and root necrosis of MM.106 apple rootstocks inoculated or uninoculated with *Pratylenchus penetrans.*

Treatment	Shoot fresh wt (g)	Root fresh wt (g)	Root necrosis index[y]	No. *P. penetrans*[x] /g root	No. *P. penetrans*[x] /100 cc soil
High moisture uninoculated	51.1 a	19.5 a	1.1 a	< 1 a	< 1 a
High moisture inoculated	42.3 b	19.4 a	2.4 b	1989 b	136 b
Low moisture uninoculated	41.9 b	14.9 b	1.5 a	< 1 a	< 1 a
Low moisture inoculated	36.8 c	14.0 b	3.4 c	1786 b	118 b

[x] Recovered at harvest.

[y] Root necrosis was rated on a scale of 1–5: 1 = 0–20% necrosis; 5 = 81–100% necrosis.

Means in a column followed by same letter are not significantly different at 5% level as determined by Duncan's multiple-range test.

primarily by reducing root quantity and depth. In this investigation, inoculation did not suppress root weight. Perhaps a soil moisture-nematode interaction would have been observed had the experiment been conducted long enough to allow root weight suppression to occur. Depth of rooting may also be an important factor. The healthy tree in the field may be subjected to less water stress than the diseased tree if its roots are able to grow deeper into the soil and thus obtain water at a higher potential.

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